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THE JAPANESE BEETLE

IMPORTANCE, LIFE HISTORY, AND CONTROL

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The Japanese Beetle

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THE JAPANESE BEETLE (*Popillia japonica* Newman) was first found in the United States near Philadelphia in 1916. It is a native of Japan. This pest reached New York State in the 1920's and has become generally distributed on Long Island, in the Hudson and Mohawk valleys and in localized areas in much of central and western New York.

Description

THE ADULT Japanese beetle is easily recognized by the metallic green body, reddish bronze wing covers, and a row of twelve white spots along the sides and rear (cover illustration). It is about $\frac{1}{2}$ inch long.

The larva, or grub, develops in the soil. When full-grown in the spring, it is about 1 inch long. As shown in figure 1, the grub normally lies curled like a letter C. It is grayish white, with a brownish head and three pairs of legs under the forepart of the body. The Japanese beetle grub is similar in appearance to the grub of several native insects, such as the May beetle or "Junebug," and to grubs of the introduced Asiatic garden beetle, oriental beetle, masked chafer, and European chafer. With a hand lens, the Japanese beetle grub can be distinguished by the presence of a V-shaped row of spines on the underside of the last segment of the body. The position and appearance of these spines is indicated in figures 3 and 4.



Figure 1. JAPANESE BEETLE GRUB
VIEWED FROM THE SIDE
Four times natural size



Figure 2. JAPANESE BEETLE GRUB
VIEWED FROM ABOVE
Four times natural size

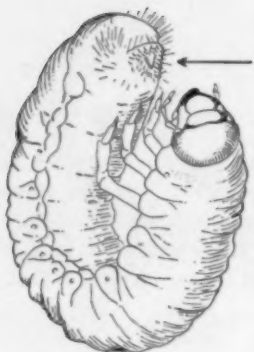


Figure 3. POSITION OF THE IDENTIFYING SPINES ON THE GRUB (ARROW)

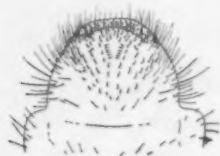


Figure 4. REAR-VENTRAL PORTION OF JAPANESE BEETLE GRUB
Note two rows of spines forming a "V"

Injury by the Adult Beetle

THE ADULT Japanese beetle flies and feeds most actively on warm bright days in July, August, and September. The beetles tend to feed in social groups, devouring the leaves, flowers, or fruits of many kinds of plants. They eat the tissues between the veins of the leaves so only a skeleton of the leaf remains to dry out and turn brown.

The beetles feed on many kinds of plants, but show a preference for grape, raspberry, early apples and peaches, sweet cherry, plum, linden, willow, chestnut, elm, horse chestnut, sassafras, rose, zinnia, soybeans, and corn silk. Frequently they damage buttonwood, birch, lombardy poplar, Norway maple, Japanese maple, and pin oak.

Not all plants require protection. Pears and most vegetable and field crops are not attacked. When one selects ornamental plant materials it is well to consider those relatively immune to beetle attack. Included are almost all evergreens, forsythia, honeysuckle, hydrangea, lilac, mock orange, privet, spirea, dogwood, magnolia, hackberry, mulberry, tulip tree, sweet gum, most maples, and most oaks.

Control of the Adult Beetle

WHEN the beetles fly into gardens and orchards in great numbers, they are difficult to control. Although some are easily killed, others soon take their place and continue the damage. Measures taken to control the grubs in turf will lessen the number of adults emerging in summer. The distribution of milky disease and parasites as discussed on page 7 is of great importance. Chemical grub control on turf reduces injury by the adults in the immediate vicinity.

DDT is the most effective insecticide for control of the adult beetles. Two pounds of 50 per cent DDT wettable powder should be mixed with each

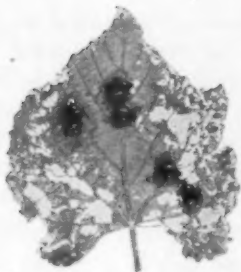


Figure 5. JAPANESE BEETLES
FEEDING ON GRAPE LEAVES



Figure 6. APPLE LEAF SKELETONIZED
BY THE JAPANESE BEETLE

100 gallons of water. This concentration roughly equals $1\frac{1}{2}$ level tablespoons a gallon. Commercial emulsifiable DDT solutions are effective and leave less visible residue. The solvents used may, however, injure some ornamentals, so manufacturers' directions and precautions should be followed carefully. Dusting the plants with 5 per cent DDT dust is also effective, but may require weekly applications especially in rainy weather. Beetles contacting DDT sprayed foliage may not drop off immediately, but will soon be killed.

DDT treatment, in some instances, has increased damage by mites. One should watch treated plants and be prepared to control mites. Where mites are a problem it may be advisable to use *lead arsenate* to control Japanese beetles with 6 pounds of lead arsenate and 4 pounds of wheat flour in 100 gallons of water. This is equivalent to 3 tablespoonfuls of lead arsenate and $2\frac{1}{2}$ tablespoonfuls of flour for 1 gallon of water. The lead arsenate spray is much less effective than DDT in killing beetles, but it has considerable repellent effect. *Do not use lead arsenate on peach or plum trees as it may burn the foliage.*

Applications should be started when Japanese beetles first appear in numbers. Thorough treatment should be given to all trees and shrubs preferred by the beetles. A spray deposit of DDT remains active for about two weeks, after which further treatment may be necessary.

Treatment of commercial crops, such as peaches, should be worked into the regular fruit-spray schedule. Up-to-date advice on spray schedules may be obtained through the County Agricultural Extension Service. Precautions should be taken to prevent harmful insecticide residues on edible crops. *Edible portions of crops should not be treated with DDT within three weeks of harvest.* Only plants attractive to Japanese beetles should be treated.

Non-poisonous sprays and dusts containing *rotenone* may be used instead of DDT to protect vegetables, berries, and fruits near harvest time. Dusts should contain from $\frac{3}{4}$ to 1 per cent rotenone (available as "Bean beetle

dust"), or sprays should contain 1 quart of 1 per cent rotenone emulsifiable solution in each 100 gallons of water. Another effective insecticide considered less toxic to man than DDT is *methoxychlor*. Methoxychlor should be used at the rate of 2 pounds of 50 per cent wettable powder in each 100 gallons of spray, or as a 5 per cent dust. Weekly treatments are suggested where these insecticides are used. Even *hydrated lime* dusted on heavily and frequently gives some protection and is non-poisonous.

Japanese beetles can be excluded from valuable plants by covering the plants with nets or screen cages. Rose buds are difficult to protect in any way except by covering to exclude beetles. When beetles are numerous in summer, it is well to disbud roses and to await a bloom after the beetles are gone in the fall. Traps baited with aromatic oils have been used to attract and catch large numbers of these insects, but are not recommended because these beetles, drawn to the vicinity of the traps, may feed heavily before the traps catch them.

Grub Injury and Its Relation to Life History

THE JAPANESE BEETLE grub is a serious pest of turf. It lives in the soil and feeds upon the roots of grasses and other plants. Turf injury caused by the Japanese beetle usually shows up in May and June when the ground becomes dry, also in September and October. Injury appears as a browning and thinning of the grass, usually in patches in sunny lawn areas. Grass may be partly or entirely killed in large areas and the turf so loosened that it can be rolled up like a rug (figure 7). Since turf impairment may result from other causes, mere browning and thinning of the grass should not be attributed to grubs unless examination of the turf shows that grubs are present. Occasionally, plants such as strawberries and nursery stock may be injured. This usually happens when such plantings are made on land previously in sod.

The adult beetle digs from 2 to 3 inches into the soil to lay its eggs. This is mainly during July and August. The young grubs hatch in about twelve days and soon begin to feed on grass roots. When the grubs are abundant, this feeding in August, September, and October may cause severe injury to the turf. In late October the grubs, now about $\frac{3}{4}$ inches long, work downwards to a depth of 5 to 8 inches to spend the winter. About April 1 these grubs begin to migrate towards the grass roots in the upper layers of the soil. The grubs feed heavily during late April, May, and June. Feeding at this time by the large grubs may cause severe injury to the turf. During June and early July the grubs change to cream or tan-colored pupae, in which stage they transform to adult beetles. The adults emerge from the ground

mostly in July and August. This pest has only one generation a year. This life history is illustrated in figure 8.

Turf that is unthrifty or dying out in patches should be examined for beetle grubs. Square-foot samples should be taken to a depth of 3 inches in the spring or fall. The sod should be picked apart over a large sheet of cardboard, and the soil should be carefully examined. Turf may be in danger of damage if more than 10 Japanese beetle grubs are found in a square foot. Grubs may be examined for identity as shown in figure 4, or they may be preserved in a small bottle containing denatured or rubbing alcohol and mailed to the Entomology Department, Cornell University Agricultural Experiment Station at Ithaca, New York, for identification. Fortunately, the same chemical treatments will control the most important grub species on Long Island and the lower Hudson Valley. In central, western and northern New York, however, the native white grubs (May beetle larvae) often are serious in turf, and require special treatment. Identification is particularly important in these areas.



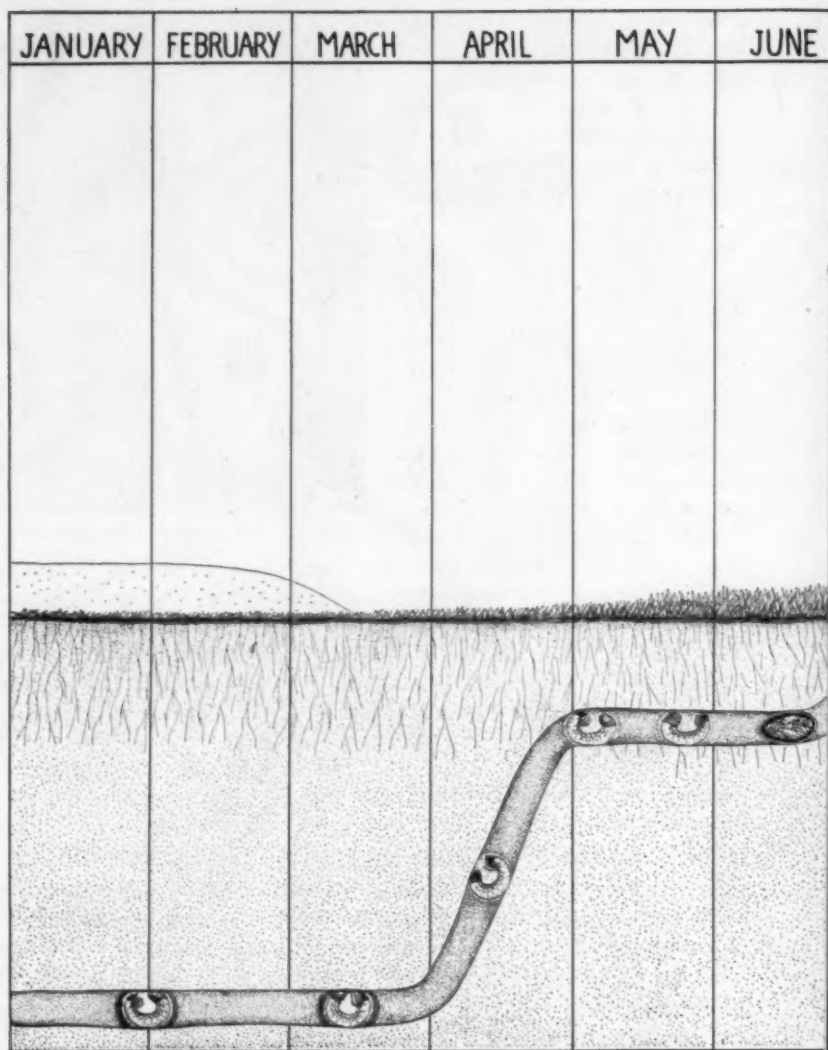
Figure 7. GRUBS UNDER DAMAGED TURF

Control of the Grubs in Turf

Diseases and parasites

EVER since the Japanese beetle was first found in the United States there has been an intensive program of seeking and introducing parasites and diseases of this pest. By now these measures have reduced its abundance in the older areas of infestation. The most successful biological control measure has been the milky white disease. This is a disease of the grub caused by a bacterial organism. The milky white color of diseased grubs is due to billions of bacterial spores in the body fluid. When the grub succumbs to the disease, the spores are liberated in the soil. Such spores remain viable for years, ready to infect and kill subsequent generations of the pest.

Practical use of this disease is made by treating the soil of grub-infested areas with a mixture of spores of the bacteria with talc and chalk, called *milky-disease spore powder*. State agencies in cooperation with Federal



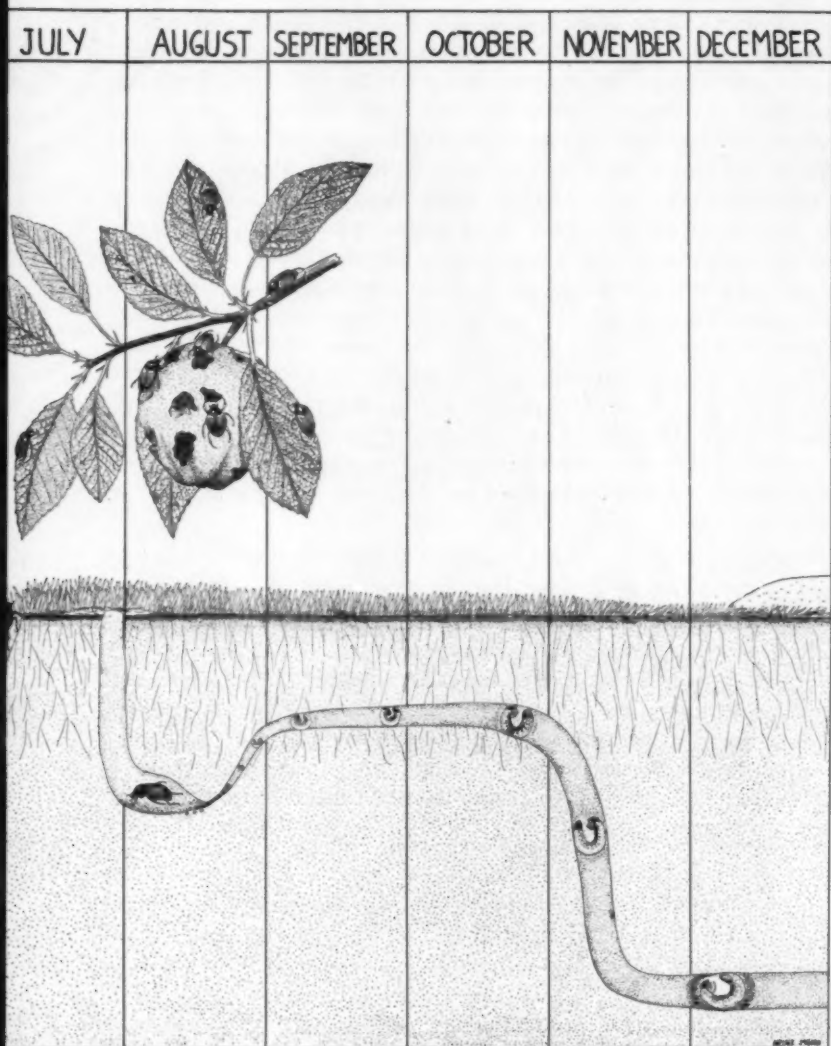
Grubs hibernate from 5 to 8 inches down in the soil

Grubs migrate upward to the grass roots

Large grubs feed heavily on grass roots

Grubs change to pupae

Figure 8. LIFE HISTOR



Adult
beetles
emerge
from turf

Beetles lay
eggs in soil
and new
grubs hatch

Growing grubs feed on
grass roots

Grubs
migrate
downward to
hibernate

Grubs
hibernate

*July to September, beetles feed on leaves,
flowers, and fruits, and then die*

THE JAPANESE BEETLE

agencies have applied this spore powder on scattered turf areas in a program to initiate spread of the disease. The spore powder is also available commercially and can be applied by anyone interested in reducing the beetle. The spore powder must not be spread evenly over the surface of the soil but rather placed in measured amounts in small spots. Ordinarily, these spots should be at 10-foot intervals in rows 10 feet apart. A level teaspoonful (2 grams) of the dust is placed in each spot. At this rate, 1 pound of spore dust will treat one-half acre. Heavier treatments, such as the same spot dosage at 3- or 5-foot intervals, speed up the establishment of the disease (table 1.) Once established in the soil, the disease bacteria multiply in the dying grubs of successive generations. Only one application is needed, as the organism perpetuates itself indefinitely in the soil. The disease is harmless to man and other animals. It must be stressed that the disease requires several years to build up to the point where grubs will not injure the turf. The slowness of the disease rules it out for valuable turf areas that must be protected immediately against the grubs. Also, it is ineffective as a control for all other turf which is not to be chemically treated but is a source of beetles. It is most effective in warm sunny locations and may prove very slow in action in northern New York.

Chemical treatments should not be applied to areas where previous milky-disease treatments are keeping the grubs in check unless the area is endangered by other grub species.

Certain parasitic flies and wasps have been introduced into the Japanese-beetle-infested areas by the United States Department of Agriculture and cooperating State agencies. The spring tiphia is the most important of these. It has become well established and is a help in the control of the beetle. There is little the property owner can do to further this program, as it would not be feasible for him to attempt the establishment of these parasites on his own property.

TABLE 1. AMOUNTS OF MILKY-DISEASE SPORE POWDER
NEEDED TO TREAT TURF AREAS.*

Spacings of spots of one teaspoonful each.	Amount to use on:	
	1000 square feet of lawn area	1 acre of turf
10-foot spacing (light rate)	0.8 ounce	2 pounds
5-foot spacing (medium rate)	3 ounces	8 pounds
3-foot spacing (heavy rate)	8 ounces	21 pounds

*Addresses of commercial suppliers of milky disease spore powder may be obtained by writing to the Entomology Department, Cornell University Agricultural Experiment Station, Ithaca, N. Y.

Insecticides

Several newer insecticides, notably dieldrin, chlordane, and heptachlor, are powerful weapons for killing grubs in turf and maintaining turf in grub-proofed condition. These insecticides are suggested for use on most home lawns and other lawns where appearance and soundness of the turf are important. The chemical treatments have certain advantages over milky disease. They act upon all the turf-damaging species likely to occur in New York. After application they act more rapidly and thoroughly. If properly applied, they penetrate the grass-root layer where grubs feed and kill the grubs. Where the sod is thin and porous, they may kill most of the grubs (in warm weather) within a few weeks. Where the sod is thick and compact, penetration will be slower but control of the next grub generation should be complete.

The number of years a single application of one of these insecticides will keep the turf free from grubs varies with the kind of insecticide used and conditions in the turf. Yearly examination of the turf is advised. It is unwise to treat more often than necessary.

Dieldrin

Dieldrin is a preferred insecticide for grub control, because it has been found highly effective and persistent in turf. One application will give control for at least 5 years and possibly 10 or more. It is effective against all grub species injurious to turf in New York. Dieldrin is more toxic to man and animals than chlordane and DDT and more care should be exercised when using it. Note that the quantity of dieldrin recommended (equivalent to three pounds of actual dieldrin to the acre) is less than that for chlordane.

Chlordane

This insecticide has been in use longer than dieldrin and has also proved highly effective. Applied at 10 pounds of actual chlordane to the acre, it usually stops turf injury within a few weeks and is still effective several years after application. For the home owner either chlordane or dieldrin is satisfactory.

Heptachlor

Heptachlor is the most rapid-acting of the insecticides here recommended. Use heptachlor if very rapid penetration and grub-kill are necessary to save the turf. Heptachlor is less persistent in the soil, so that re-treatment may be necessary in 2 or 3 years. Only 2 pounds of actual heptachlor are required to treat an acre.

DDT

Applications of DDT at 25 pounds of actual DDT to the acre have given control of Japanese beetle grubs for 10 years and more. However, DDT is no longer to be generally recommended for grub control as it does not satisfactorily control several species injurious to turf in New York, including certain common native white grubs or May beetle larvae. It is slower in action and, in the quantity stated, it is more expensive than other insecticides mentioned.

Lead arsenate

Lead arsenate has been used successfully for years to grub-proof turf, but requires 450 pounds of insecticide an acre, or 10 pounds to 100 square feet. Because such a treatment is much more costly than DDT or chlordane, it is not suggested for most lawn areas. Lead arsenate, however, should be used in areas where control of common earthworms as well as grubs is desired, as on golf greens and tees.

How to apply

Chemical grub-proofing requires even and thorough application of the insecticide regardless of the material used. The actual amounts of the various finished insecticides needed for small and large turf areas are given in table 2. One of the easiest ways to apply these amounts evenly is to use an ordinary fertilizer or lime spreader. Applications of this sort should be made with insecticides made up in granulated form. Two forms are available: one made with attapulgate or bentonite granules which spreads about like fertilizer; and the other with tobacco waste or vermiculite, which are lighter and bulkier than fertilizer. Using low-percentage granulated insecticides in the commoner type of spreaders available may require an aperture less than one-quarter open for attapulgate or bentonite and a little more than half open for tobacco waste or vermiculite. No exact recommendation for spreading can be given. The spreader should be adjusted by weighing the amount run out over a known area of ground. Put in a weighed amount of granulated insecticide, spread over 100 square feet and weigh what is left in the spreader. The difference between the two weighings multiplied by 10 will give the rate per 1000 square feet. Of course the walking speed should not be changed once the adjustment is completed.

If dry dust is used, mix the quantity of insecticide dust needed for each 1000 square feet with from 5 to 10 pounds of dry granular material, such as activated sludge fertilizer. Mixing may be done in a cardboard drum with a tight-fitting lid. Avoid inhaling the dust. This method is particularly adapted to home-lawn treatment, using ordinary lime or fertilizer spreaders.

TABLE 2. AMOUNTS OF INSECTICIDES NEEDED TO TREAT TURF AREAS

Insecticides	Amount to use on:	
	1000 square feet of lawn area	1 acre of turf
Granulated or dry dust		
1% dieldrin granulated or dust	8 pounds	300 pounds
2% " " or "	4 pounds	150 pounds
5% " " or "	26 ounces	60 pounds
2½% chlordane " or "	10 pounds	400 pounds
5% " " or "	5 pounds	200 pounds
10% " " or "	2½ pounds	100 pounds
2½% heptachlor " or "	25 ounces	80 pounds
Wet Spray		
25% dieldrin wettable powder	5 ounces	12 pounds
18.5% dieldrin emulsifiable solution ¹	6 liq. ounces	2 gallons
40% chlordane wettable powder	10 ounces	25 pounds
50% " " "	8 ounces	20 pounds
75% chlordane emulsifiable solution ²	4 liq. ounces	5 quarts
25% heptachlor wettable powder	3½ ounces	8 pounds
25% heptachlor emulsifiable solution ³	3½ liq. ounces	1 gallon

¹Contains 1.5 pounds dieldrin per gallon.²Contains 8 pounds of chlordane per gallon. For others available calculate dosage on basis of chlordane content per gallon.³Contains 2 pounds of heptachlor per gallon.

The effectiveness and safety of the operation should be increased by thoroughly watering the insecticide into the turf after the application.

The insecticides may also be applied as wet sprays. The amount shown in the lower part of table 2 should be mixed with enough water to wet evenly the area to be treated. The actual amount of water necessary depends on the type of equipment used. A sprinkling can may be used to treat small lawns, and will require about 25 gallons of water for each 1000 square feet. A power sprayer equipped with a spray boom is efficient for large acreages, and may require only a few hundred gallons of water to the acre.

Low gallonage spraying

Low-gallonage sprayers, such as those used for weed control with 2,4-D, may be effectively used for turf-insect control. 20 gallons of water per acre may be used rather than the 250 to 1000 gallons of water necessary in ordinary sprayers. Gear or other rotary pumps are usually used to pump the insecticide through fine flat spray nozzles in a long boom. It is usual to maintain 40 pounds per square inch liquid pressure. Although treatment can be made at the rate of 10 gallons per acre, it is suggested that 20 gallons per

acre is safer and more foolproof. For grub-proofing, $1\frac{1}{4}$ gallons of 75 per cent chlordane emulsifiable solution and $18\frac{3}{4}$ gallons of water per acre is recommended. Effective control will also be obtained with 2 gallons of 18.5 per cent dieldrin emulsifiable solution and 18 gallons of water per acre. For combined weed control and grub control in one operation, 2,4-D solutions may be mixed into the chlordane emulsion. *Do not overdose. Do not stand still while you spray the turf or while the sprayer is dripping, as grass burn will result.* As an example of calculations, an output rate of 2 gallons per minute, through a 20-foot boom, traveling at $2\frac{1}{2}$ miles per hour, will give 20 gallons per acre. An acre will be treated in 10 minutes. *Caution:* It would be wise to avoid low-gallage treatment during a prolonged dry spell as there may be excessive insecticide decomposition before it reaches the soil.

When to apply

Grub-proofing may be done at any time of the year that it is possible to run machinery on the turf. Dieldrin, chlordane, and heptachlor applied early in the fall will prevent damage the following spring. In the spring these insecticides will often stop turf damage within 3 weeks of the time of application if the soil is warm.

Spring or early summer applications of any of these materials prevents damage the subsequent fall. Summer applications of any of these materials during dry weather should not be attempted unless followed by thorough watering-in.

Precautions

Dieldrin, Chlordane, heptachlor, lead arsenate and DDT are all poisonous to man and animals when taken internally in sufficient quantity. Due care should be exercised in handling and stirring these materials to prevent accidental ingestion. The amount used should not exceed the dosages given in table 2. These materials are lasting in the soil, and excessive dosages may be injurious to some plants. To reduce hazards to birds, it is suggested that applications to large turf areas be conducted in late fall or early spring. Thorough watering of freshly treated turf will reduce hazards to pets.

Control Programs

Home lawns

HIGHLY VALUED lawn areas require the rapid and sure protection of chemical treatments. Insecticides should be used where serious turf damage is likely. Less valued lawn areas, where some turf damage would be permissible in the next 2 years or so, may be treated with milky disease. It is desirable to start this disease among the Japanese beetle grubs in at

least one area on each property or on one property in each city block, especially in newly infested localities.

New lawns in housing developments

In the first few years after construction, lawns often become heavily infested with grubs (evidently because the new soils are deficient in natural enemies of the grubs). If the grubs are mostly larvae of the Japanese beetle, the adult beetles emerging in summer may severely damage the small, newly planted ornamentals. For such situations, a community project can be organized in which most of the lawns are grub-proofed with insecticides and the remaining lawns and grassy areas (new parks, boulevard strips, etc.) are treated with milky disease spore powder.

Golf courses

Greens and tees should be kept grub-proofed with lead arsenate. Lead arsenate should be incorporated in all new greens and tees. Fairways should be treated with dieldrin or chlordane. Mowed roughs should be treated once with milky-disease spore powder to reduce the breeding of beetles.

Parks, school grounds, cemeteries, and other public turf areas

When the Japanese beetle invades a village or suburb, the parks, school grounds, air-fields, cemeteries and other larger mowed properties which are not likely to be treated with soil insecticides, should be used for local development of milky disease. Spore powder may be distributed on half-acre plots scattered through such properties. Conspicuous portions near the entrances may require insecticides to avert turf damage. Note that it is wasteful to over-lap the two kinds of treatment.

Pastures

Areas in pasture adjoining fruit plantings or gardens may be treated with milky-disease spore powder to check the beetle population at its source.

Inspection and Certification Service

THE UNITED STATES Department of Agriculture and the New York State Department of Agriculture and Markets, at Albany, are engaged in a Japanese beetle quarantine program to retard the spread of this insect into areas not yet infested. The regulated area now includes all but certain northern and western parts of the State. Shipments, from the regulated area, of forest, field, nursery, or greenhouse-grown plants, or plant parts, as well as soil, compost, humus, and manure require federal inspection and certification. Rapid methods have been developed to prepare balled nursery stock and potted plants to be certified for such shipment. Information on the inspection and certification service may be obtained from the Division of Plant Industry, New York State Department of Agriculture and Markets, Albany.

In Brief

THE JAPANESE BEETLE is spreading in southeastern New York State and has become established locally in numerous places in central and western New York. Plants can be protected from injury by the adult beetles through the use of DDT sprays or dusts. Valuable turf areas can be protected from damage by grubs of the Japanese beetle and certain related species through the application of dieldrin, chlordane, or heptachlor. Less valuable turf areas should be treated with milky-disease spore powder, which introduces into the soil certain bacteria that multiply and spread disease in Japanese beetle grubs. The milky disease gives little benefit the first year but after a few years it helps greatly to reduce the numbers of adult beetles arising from the treated turf. Programs that combine the various control measures have been established for residential and rural areas and for golf courses. The parts of the State infested by the Japanese beetle are under Federal quarantine. Persons shipping plants and similar material out of the quarantined areas should obtain the services of Federal or State plant inspectors.



Cooperative Extension Service, New York State College of Agriculture at Cornell University and the U. S. Department of Agriculture cooperating. In furtherance of Acts of Congress May 8, June 30, 1914. M. C. Bond, Director of Extension, Ithaca, New York.